X-ray fluorescence microanalysis of speleothems using synchrotron radiation

P. Jagodziński[b], D. Banaś[a], A. Kubala-Kukuś[a], M. Pajek[a], J. Szlachetko[a], J. Susini[c]

[a]Institute of Physics, Jan Kochanowski University, 25-406 Kielce, Poland, [b]Department of Physics, Kielce University of Technology, 25-314 Kielce, Poland, [c]European Synchrotron Radiation Facility (ESRF), F-38043 Grenoble, France.

Author Email: pajek@ujk.edu.pl

X-ray fluorescence analysis (XRF) is well suited technique for investigations of the properties of geological objects. The speleothems (stalactites, stalagmites and pearls), exhibiting annual variations of trace elements concentrations, can be effectively used for monitoring of the climate changes in the past, if the XRF technique is combined with mirometer-sized intense photon beam excitation. In fact, it was demonstrated that x-ray fluorescence excited by focused microbeam of synchrotron radiation can be successfully used to study the climate changes [1].

Here we report on the x-ray fluorescence studies of stalactites and pearls samples taken from the karst "Paradise" cave, Central Poland, excited by focused x-ray photons of synchrotron radiation at the ID21 beamline of the ESRF, Grenoble. The excited x-rays were measured both by an energy-dispersive silicon drift detector (SDD) and a flat crystal wavelength-dispersive spectrometer (WDS) equipped with a polycapillary x-ray optics [2]. The WDS, operating with ADP(101), Si(111) and Ge(220) crystals, covers the x-ray energy range 1.5-6.5 keV with energy resolution 3-30 eV. The properties of this spectrometer were studied in details using ray-tracing simulation technique. The benefits of better energy resolution of the WDS, as compared to the SDD detector, for investigations of the geological samples are discussed in context of saturation and Raman scattering effects. The 1D and 2D XRF scans were measured for stalactite and pearl samples with a micrometer lateral resolution yielding the maps of concentration of six light elements between Si and K, which exhibits the annual variations. Finally, the results are discussed in context of monitoring the long-term climate changes in the past.

References

[1] S. Frisia et al., Variation in atmospheric sulphate recorded in stalagmites by synchrotron micro-XRF and XANES analysis, Earth and Planetary Science Letters 235 (2005) 729-740.

[2] J. Szlachetko et al., Wavelength-dispersive spectrometer for X-ray micro-fluorescence analysis at the X-ray microscopy beamline ID21 (ESRF), J. Sunchrotron Rad. 17 (2010) 400-408.

...